DCCUMENT BESUME

ED 153 821 SE 024 110

TITLE	Oklaroma Energy Awareress Educatiorn, Resource Materials.
INSTITUTION	Oklahoma State Dept. of Educatior, Oklahoma City.
SPONS AGENCY	Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE	77
NOTE	98p.; For related documents, see SE 024 108-109; Pages 27-28 missing from document prior to its being shipped to EDRS for filming; Certains occasional light type
EDRS PRICE	MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS	Activity Units; *Energy; *Energy Conservation; Environmental Education; *Instructional Materials; *Interdisciplinary Approach; Natural Resources; Resource Allocations; *Teaching Guides
IDENTIFIERS	*Oklahoma

ABSTRACT

This publication is the teacher's reference of a series of three energy education publications. This teacher's reference handbook provides background information and some materials to aid the teacher in using the activities in the other two publications. The many charts, graphs, and illustrations are designed to provide the teacher with graphic ways to assist students in understanding energy problems and concepts. The looseleaf construction of this publication will enable the teacher to remove specific pages for reproduction. Topics discussed in the twelve chapters of this publication include the energy conservation ethic, definition of energy, selected forms of energy used by man, future capital requirements for energy, and energy conservation in agriculture. Chapter 10 is a glossary of energy terms. Chapter 11 lists some selected sources of energy information. (MR)

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Larry McKinney

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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OKLAHOMA

ENERGY AWARENESS EDUCATION RESOURCE MATERIALS

ENERGY EDUCATION ACTIVITIES

Oklahoma State Department of Education

Leslie Fisher, State Superintendent of Public Instruction

1977

SE 024 110

"The success of any program to reduce energy consumption is dependent upon citizen action. Government and industry must play major roles, but it is the people, finally, who must accept--and ultimately demand--energy awareness and conservation and make it a way of life."

Henry L. Diamond in the Introduction to Citizen Action Guide to Energy Conservation, 1973

This publication, printed by Central Printing Division, Board of Public Affairs, State of Oklahoma, is issued by Oklahoma State Department of Education as authorized by Leslie Fisher, State Superintendent of Public Instruction. Six thousand copies have been prepared and distributed at a cost to the taxpayers of the State of Oklahoma of $8,068.09. ($1.34 cost per copy.)

Funds to publish these materials were provided by a grant under E.S.E.A., Title V, Section 503.

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ACKNOWLEDGEMENTS

Grateful appreciation is extended to the following agencies and companies who gave their human and financial encouragement and support to the Energy Awareness Work Conference.

Atlantic Richfield Company	Oklahoma Gas and Electric
Cities Service Company	Oklahoma Petroleum Council
Continental Oil Company	Oklahoma State University
Gulf Oil Company	Phillips Petroleum Company
Kerr-McGee Corporation	State Department of Education
Oil Marketers Association	State Department of Energy

A special thanks go to the following people who organized and conducted the Energy Awareness Leadership Work Conference:

Larry McKinney	State Department of Education
Howard Potts	State Department of Education
Dr. Carl Anderson	Oklahoma State University
Dr. Steven Marks	Oklahoma State University
Dr. Kenneth Wiggins	Oklahoma State University

To the participants of the Energy Awareness Work Conference who devoted much of their time to organize the Energy Education Materials:

Paula Baines	Big Cabin (Chelsea Schools)	Jimmy Myers	Tecumseh
		Jessie Nelson	Guymon
Jerry Cunningham	Owasso (Tulsa Schools)	Bud Osborne	Stillwater
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Gayla Guffy	Stillwater	Evelyn Smith	Midwest City
Pat Kellogg	Ada	Paul Southwick	Guymon
Linda Knox	Oklahoma City	Robert Walsh	Enid
Robert Moore	Kingfisher	George Zech	Duncan

To Ruth McKillen and Debbie Miller for the many hours spent typing, processing, and arranging the manuscript.

FOREWORD

Historically, American education has responded well to the "needs of the time". For example, more has already been achieved in space flight, exploration, and technology than was ever dreamed possible twenty years ago.

The worldwide energy situation demands action now. Priorities must be placed upon seeking both immediate and long-term solutions. Recent energy shortages (whether real or contrived) and their resultant economic impacts have brought general awareness and recognition that our presently utilized sources of energy, primarily fossil fuels, are finite and exhaustible. Energy for industry, transportation, homes, businesses, schools, and recreation is becoming increasingly scarce and more costly. The factors contributing to energy shortages are complex and numerous; major among them are: finite energy sources, increasing human population, and an ever-increasing per capita demand for energy consuming devices as technological spread and advancement occurs. The lives of all people are affected in some way by the energy problem.

Schools have already been affected. Schools throughout much of the country experienced closing due to lack of fuel during severe winter storms last school year. Significant increases in dollar costs for energy to operate school facilities have been and continue to be of major concern to many school districts.

Individuals must learn and accept an energy conservation ethic. Education must provide the setting for students to acquire an awareness and understanding of the present energy situation, learn how

the situation developed, and learn how energy can be used more conservatively and efficiently. Individual awareness of energy alternatives and willingness to work toward achieving feasible alternatives are needed.

Schools should provide a positive example of energy conservation to students through design, construction, maintenance and operation of the school facilities. In addition, students should experience educational activities designed to develop energy literacy and sound energy conservation habits. Hopefully, some of the students now in school will discover new sources of energy, produce new technology capable of utilizing presently untapped sources, or find different, more efficient ways to use present sources. That one student may be in your class now.

These materials have been compiled to help classroom teachers better meet these needs throughout the elementary and secondary schools of the State. It is our desire and intent that teachers will use these instructional activities as a starting point to integrate energy education into the curriculum of their school. A major effort is needed if we want to be able to continue a semblance of the life styles which we enjoy and have come to expect.

Leslie Fisher
Superintendent of Public Instruction

HOW DO I USE THIS HANDBOOK?

First, be sure to examine carefully the background information provided in the first eleven chapters.

The checklists and activities are designed to provide teachers with a wide variety of easy to use tools to help develop students' awareness of energy.

Different sections provide background materials for the teacher. The many charts, graphs, and illustrations are designed to provide the teacher with many graphic ways they can help their students understand this difficult topic. The loose leaf format will enable the teacher to remove specific pages and reproduce them.

The Bibliography and resource material section provides the teachers with additional sources they may use to investigate this complex topic.

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CHAPTER I

ENERGY

Man has been using energy since he first appeared on earth thousands of years ago. But only in the past century has man's use of energy threatened to overwhelm his environment.

Primitive man consumed energy, for the most part, in the form of food: energy from the sun was converted by photosynthesis into the plant life which he, or the animals he hunted, ate. The earth's population was scanty and demands for energy were few.

At some time in the distant past, man discovered fire and learned to use it. But it wasn't until man learned how to create fire, perhaps while chipping flint tools and weapons, that he began the journey out of the Stone Age.

When man settled down to cultivate the land, he trained animals to work for him, and for countless centuries animals supplied most of man's energy. In some parts of the world, they still do. Men also turned to other men to meet growing energy needs: the Egyptians built their pyramids with slaves, a method of harnessing solar power (humans, like animals, receive their energy indirectly from the sun through food) that other civilizations, including our own, have relied upon. But demands for energy also tapped man's creativity. The wind was made to turn windmills and push sailing ships, and water wheels began a technology that has led to the hugh hydroelectric plants of today.

The industrial revolution brought machines for converting energy from one form to another that irrevocably changed man's

life and his relationship to his environment. First came the steam engine, and then, within a short time, the internal-combustion engine--and both had relentless appetites for new fuels. Coal for the steam engine replaced wood as the primary source of energy in the industrialized societies, and as the internal-combustion engine was accepted, the demand for oil grew.

The steam engine made energy portable on a large scale for the first time: factories no longer had to be near rivers, and locomotives and steamboats revolutionized transportation. Electricity brought new uses for the steam engine: less than 100 years ago, a coal-fired steam engine was joined to a generator and the first central-power-generating station turned on the lights of New York City. Electricity is now essential to our civilization.

Petroleum products, before the internal-combustion engine, had been used mainly for patent medicines, although kerosene had replaced whale oil and candles and was beginning to be used for heating. Gasoline, however, had been a wasted by-product. Now, the millions of cars, trucks, and buses crowding our highways are all powered by internal combustion engines; so are the airplanes, ships, and trains. All of them depend on petroleum for fuel.

Another form of energy is now playing a significant role: the atom. Albert Einstein's theoretical basis for nuclear fission, $E=mc^2$, was formulated in 1905. But it was not until 1942 that scientists in Chicago, working under Enrico Fermi, created the first self-sustaining nuclear chain reaction. This new form of energy was first used for weapons--the atomic bombs that brought World War II to a devastating, but conclusive end. Following the war, however,

peaceful applications of nuclear energy were pursued and 12 years later the first large-scale commercial nuclear power plant began generating electricity in Shippingport, Pennsylvania.

Today, we draw our energy from a variety of sources, primarily from running water, fossil fuels, and nuclear fission. In the past few years, however, we have been forced to realize that fossil fuels are finite and that we have been wasteful with resources that had always seemed limitless. Now, we must use these fuels more wisely and develop new sources of energy.

In the U.S., we use more than 30 times the energy we used 100 years ago--but the population has increased only seven-fold. This means that each American is using about four times more energy than his great-grandparents. Every person in this country uses approximately 400 million BTU's (100 million kilocalories) of energy each year: twice as much as a person in Great Britain, three times as much as the average French citizen, and from 10 to 100 times the amount of someone in a developing country. We have only 6 percent of the world's population, yet we consume about one-third of the world's energy. But, consideration should be given to the fact that much of this energy is used to produce goods and services for consumption elsewhere in the world.

A. The Energy Crisis: How Did It Happen?[1]

On October 16, 1973, the Organization of Arab Petroleum Exporting Countries (OAPEC) imposed an embargo on shipments of oil to

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[1]"The Energy Crisis: How Did It Happen?" Energy Reporter, FEA (Washington, D.C.: Office of Communications and Public Affairs, December 1976/January 1977).

the United States and the Netherlands, supporting it with production cutbacks of 5 percent. The following month, the embargo tightened as OAPEC cut production further by 25 percent.

The implications for the U.S. economy were obvious. With 22 percent of our oil imports coming from Arab nations, there was, in some areas of the country, the real prospect of factory closings and widespread unemployment. The embargo threatened to become much more than an inconvenience for gasoline-hungry motorists. It had all the potential of a full-blown economic crisis. To understand how this country could be placed in such a vulnerable position is to understand its energy history.

When the Industrial Revolution converted the United States from a lightly-populated agrarian society to the dominant economic force in the world, America's energy requirements were insignificant compared to its vast energy wealth.

As recently as 1920, coal supplied almost 80 percent of this country's energy needs. It was used in steel production and other industrial processes, in transportation to power ships and locomotives, as a source of heat for homes and buildings, and to generate electricity.

Up to and during World War II, the U.S. economy was based primarily on our vast reserves of coal. (Coal still makes up 90 percent of our recoverable energy resources.) However, the percentage of energy supplied by coal, as opposed to the percentage supplied by petroleum (which accounts for only 7 percent of our known energy reserves), had begun to diminish.

Originally, petroleum products were regarded chiefly as illuminants and lubricants, but with the rise of the automobile, gasoline became the dominant need.

Highways began to supplant the railroads as the Nation's most important travel conduits, both for passengers and freight. The deterioration of the railroads, ironically, speeded the shift from coal to oil, since coal could only be moved in large quantities by rail. In yet another irony, the postwar period saw the coal-fired locomotive replaced by electrified and diesel-powered engines.

Oil and gas were easier to extract, easier to transport via a burgeoning pipeline system, and more efficient and cleaner to burn. Equally important, they were competitive in price. Those factors virtually removed coal as a source of heat for homes and commercial buildings. Its use also was restrained by electric utilities through environmental laws regulating sulfur dioxide emissions into the air.

Wellhead price controls on natural gas, in effect since the 1930s, made it an increasingly attractive commodity, and numerous industries began converting to natural gas for manufacturing processes. The 1940s and 1950s saw whole new industries, such as petrochemicals, plastics, and fertilizers, using oil and cheap natural gas as raw materials.

From the perspective of the energy crisis, the importance of all these trends is not so much that coal production has remained at the level of the 1930s but that coal use, as a percentage of total energy use in this country, has fallen drastically. From 80 percent in 1920, coal had fallen to 38 percent by 1950 and to less than 20 percent by 1973.

The coal was, of course, replaced by oil and gas which met 18 percent of our 1920 demand, 57 percent of 1950 demand, and almost 80 percent of 1973 requirements.

Still, there was enough, and it was cheap. For decades, oil and gas price increases stayed far below the inflation rate. Their relatively low prices led to wasteful and inefficient use in gas-guzzling cars, industrial processes, and utility boilers. The energy binge increased steadily, the annual rate of increase peaking in the 1960s. Between 1965 and 1973, our consumption of energy, most of it from oil, had been growing at an annual average rate of almost 5 percent.

Although the United States had imported some oil for decades, it was largely because the imports were priced lower than domestic petroleum or, as on the east coast, because it was more desirable to import distillate and residual oils than to build refineries.

Import cutoffs could be, and were, made up by cranking out spare U.S. capacity. Three times prior to 1973, Arab-Israeli hostilities led to oil embargoes. Each time the United States made up the deficit out of idle capacity, and even exported oil to other countries to get them through the emergencies.

The three previous embargoes failed because they were the initiatives of individual Arab countries, because the multinational oil companies still were able to exert considerable influence and, mainly, because most U.S. imports came from non-Arab exporters such as Canada, Venezuela, and Indonesia.

By October 1973, the situation had changed. The Organization of Petroleum Exporting Countries (OPEC), created in 1960 in resporse

to a planned price reduction by the multinational oil companies, had largely taken control of their own national oil reserves. The Arab countries among them were able to present a united front.

More important, the United States no longer had spare capacity with which to respond. Domestic oil production had peaked in 1970 at about 9.6 million barrels per day and was declining. Demand for oil was still increasing rapidly, and to meet it, imports had risen from a manageable 18 percent in 1957 to a dependent 36 percent in 1973. Fourteen percent of our total oil needs came from Arab countries.

Prior to the embargo, rumblings of the future oil shortage had been heard. Gasoline and heating oil supplies had been tight the two previous years, and legislation to allocate scarce oil products had already passed the Senate and was pending in the House. Moreover, we had come to the shocking realization that we lacked enough domestic refining capacity to turn all available crude oil into product.

Since the end of the embargo, the government has found that resolving the energy problem is not as simple as loosening OPEC's hand on the oil spigot. Energy has such a pervasive effect on our lives, and the wasteful trends are so firmly established, that there just is not a short-term solution.

B. A Chronology of America's Energy Crisis

December 1976 marked the third anniversary of FEA. To commemorate the event, this issue of *Energy Reporter* leads off with the story "How Did It Happen?" which traces the crucial historical

factors that precipitated the 1973 energy crisis. The following article, "Milestones," retraces key energy events of the past three years.

1973

OCTOBER

The Organization of Petroleum Exporting Countries (OPEC) raises the world price for crude oil from $3.00 to $5.12 per barrel.

The Organization of Arab Petroleum Exporting Countries (OAPEC) announces a 5 percent crude oil production cutback and an embargo on sales of oil to the United States.

NOVEMBER

OAPEC announces a 25 percent crude oil production cutback.

The President signs the Trans-Alaska Pipeline Act of 1973 which authorizes construction of a pipeline from Prudhoe Bay on the North Slope to the ice-free port of Valdez on the southern coast.

The President announces immediate emergency energy measures: aircraft fuel allocation reductions, federal government fuel consumption reductions, and proposed emergency legislation.

The President signs the Emergency Petroleum Allocation Act of 1973 (EPAA) requiring the allocation of crude and residual fuel oil and most refined petroleum products manufactured in, or imported into, the United States.

DECEMBER

The Federal Energy Office (FEO) is created by Executive Order to implement the EPAA and deal with petroleum shortages resulting from the oil embargo.

OPEC increases the world price of crude oil from $5.12 to $11.65 per barrel.

The Department of the Interior releases data indicating that, for the entire year of 1973, imports of oil accounted for 36.6 percent of total domestic energy consumption.

1974

JANUARY

The President signs a bill setting a maximum speed limit of 55 miles per hour for all vehicles traveling on interstate highways.

FEO announces the Mandatory Petroleum Price and Allocation Program, regulating prices for, and allocating, some crude oil and petroleum products.

Controls are placed on certain U.S. petroleum exports.

The construction permit is issued for the trans-Alaska oil pipeline, granting a right-of-way across federal lands.

FEBRUARY

The United States convenes the Washington Energy Conference of 13 industrial nations to discuss emergency and long-term energy cooperation, leading to creation of the Energy Coordinating Group.

MARCH

The President signs the Federal Energy Administration Act of 1974, creating the Federal Energy Administration (FEA) with authority for fuel allocation and pricing regulation (under EPAA), data collection and analysis and energy planning.

JUNE

The President signs the Energy Supply and Environmental Coordination Act of 1974 (ESECA), authorizing FEA to take steps to increase the use of coal in power-plant boilers so that scarce oil and natural gas may be redirected to higher priority uses.

SEPTEMBER

FEA awards $10 million to the states for programs of energy allocation, conservation, resource development and management.

OCTOBER

The President signs the Solar Energy Research, Development, and Demonstration Act of 1974 providing for research and assessment of solar energy and development and demonstration of practicable means for solar commercialization.

NOVEMBER

FEA issues the *Project Independence Report*, the most comprehensive energy analysis undertaken by the federal government, which evaluates the Nation's energy problems and provides a framework for developing a national energy policy.

The President signs the Energy Reorganization Act of 1974, creating the Energy Research and Development Administration, the Energy Resources Council and the Nuclear Regulatory Commission.

The 18-nation International Energy Agency (IEA) is established to implement a program of emergency and long-term energy cooperation, replacing the Energy Coordinating Group.

The Department of the Interior announces a schedule for acreage leasing on the Atlantic Outer Continental Shelf for exploration,

development and production of oil and natural gas.

FEA sends its first report to Congress on foreign ownership of, and controls and influence on, domestic energy sources and supply.

The Department of the Interior releases data indicating that for the entire year of 1974, imports of oil increased to 36.7 percent of total domestic energy consumption.

1975

JANUARY

The President delivers the "State of the Union Message" on energy and the economy, outlining the Nation's energy goals and a national energy policy to achieve them.

FEA releases the Krueger study, *An Evaluation of the Options of the U.S. Government in its Relationships with U.S. Firms in International Petroleum Affairs.*

The President announces a fuel economy target of 18.7 miles per gallon for 1980 model domestic cars, representing a 40 percent improvement in fuel economy over 1974 model cars. Domestic automobile manufacturers agree to try to achieve the goal.

The President implements the supplementary oil import fee program charging additional crude oil import fees of $1 per barrel effective February 1st and $2 per barrel effective June 1st.

MARCH

The first section of the trans-Alaska oil pipeline is put into place.

JULY

FEA issues orders to 41 utility companies in 25 states requiring that certain proposed powerplants be designed and contructed with

coal-burning capability.

IEA establishes the first world crude oil cost- and price-reporting system.

OCTOBER

OPEC increases the world price of crude oil from $11.65 to $12.38 per barrel.

DECEMBER

The President signs the Energy Policy and Conservation Act of 1975, providing for a composite price for all domestic crude oil and for decontrol of crude oil and refined products within 39 months, when the controls authority would convert to standby status. The Act also provides for automobile fuel economy standards, automobile and appliance fuel economy labeling, coal conversion authority and other energy conservation provisions. The Act further provides for a strategic petroleum reserve program and for implementation of U.S. obligations under IEA's emergency oil-sharing program.

The first session of the Conference on International Economic Cooperation meets in Paris, creating a commission on energy.

The Department of the Interior releases data indicating that, for the entire year of 1975, imports of oil to the United States increased to 37 percent of total domestic energy consumption.

1976

JANUARY

FEA establishes the Canadian Crude Oil Allocation Program, which encourages crude oil exchanges among land-locked U.S. refiners dependent on Canadian crude oil.

MARCH

IEA's Long-Term Cooperation Program becomes effective, committing member nations to reduced dependence on imported oil and to the establishment of joint projects for accelerated energy development.

APRIL

The President signs the Naval Petroleum Reserves Production Act of 1976 authorizing exploration, development, and production of the Naval Petroleum Reserves in Elk Hills and Buena Vista, California, and Teapot Dome, Wyoming.

JUNE

Price and allocation controls are removed from residual fuel oil.

The California Nuclear Safeguards Initiative, the first public referendum of its kind, is defeated.

JULY

Price and allocation controls are removed from middle distillate fuels.

The Federal Power Commission issues an opinion nearly tripling the price producers can charge for natural gas sold in interstate commerce and produced from wells begun on, or after, January 1, 1975.

AUGUST

The President signs the Energy Conservation and Production Act, extending the life of FEA through 1977 and providing for rate design initiatives for electric utilities, conservation standards for new buildings and financial assistance for weatherization of

existing buildings.

SEPTEMBER

Price and allocation controls are removed from naphtha-based jet fuel.

The Environmental Protection Agency releases fuel economy figures for 1977 model domestic cars, indicating a 34 percent fuel economy improvement over 1974 model cars.

OCTOBER

The President signs the Alaska Natural Gas Transportation Act of 1976, authorizing the federal government to consider alternative routes for transportation of natural gas from Alaska to the lower 48 states and requiring the President to make a decision on a route in 1977.

NOVEMBER

The Department of the Interior suspends all oil shale leases for one year.

IEA completes a successful test of detailed procedures for international allocation of oil in the event of a supply interruption.

DECEMBER

FEA issues a draft study on alternatives for transporting oil from Alaska to the lower 48 states.

The last pipe is laid for the trans-Alaska oil pipeline, less than two years after the pipe-laying began.

FEA sends to Congress the Strategic Storage Reserve Plan, calling for a total reserve of 500 million barrels of oil to be in storage by the end of 1982.

FEA and the Department of the Interior release preliminary data indicating that, for the entire year of 1976, imports of oil would increase to 41.7 percent of total domestic energy consumption.

OPEC meets in Doha, Qatar, to set basic world prices for crude oil starting January 1, 1977.

CHAPTER II

POPULATION

Each day, the average American uses the energy from 13.6 pounds (6.2 kilograms) of coal, 3.3 gallons (12.5 liters) of oil, 297 cubic feet (8.4 cubic meters) of natural gas, 3.7 kilowatt hours (3.2 calories) of hydroelectric power and .7 kilowatt hours (.6 calorie) of nuclear power. A baby born today will consume during his lifetime, 175 tons (1.6×10^5 kilograms) of coal, 2000 barrels (319 kiloliters) of oil, and 7.5 million cubic feet (212 thousand cubic meters) of natural gas. And that's based on today's rate of consumption--a rate that is growing steadily.

Simple arithmetic tells us that if the population continues to grow, we will be using considerably more energy. The U.S. birth rate has leveled off; but even so, the population continues to grow. At the present rate, the population will not stabilize until it reaches 275 to 300 million.

In other parts of the world, particularly in the developing areas, populations are growing rapidly and each new baby further strains already inadequate energy resources. Thus, if developing areas are to grow economically, it seems clear that they must first deal with the population problem. But the rich nations, too, must control population growth. If not, there simply will not be enough energy to go around, unless per capita energy consumption is held steady or reduced--and that seems unlikely.

CHAPTER III

ENERGY CONSERVATION ETHIC

For years the concern for proper conservation of natural resources was confined to a very small group of serious minded conservationists. The general population felt that unlimited natural resources were available and that there was little need for the average citizen to be concerned about the wise use of these resources.

Although many people warned of the critical need to practice conservation, and to consider the potential limit of our resources, they were often thought of as people who wanted to go back to a cave existence. In addition, these individuals were often considered prophets of doom in their predictions. Consequently, the throw-away society flourished almost unchallenged.

In the early 70s, the conservation ethic took on a new form. The need to avoid the waste of resources and to consider environmental degradation was supported by a larger, more vocal group of citizens.

Now the energy problem is on the minds of practically every citizen. However, there are still many who refuse to believe that the crisis is real and who continue to find excuses for justifying continued waste.

Hopefully, we will finally begin to take to heart what the conservationists have been telling us for years: the world is finite, our resources are finite, and, if we wish to maintain a comfortable life style in a technological society, we must adopt

the conservation ethic in place of the throw-away ethic. The quality of our future existence depends on it.

WHY STUDY ENERGY?

Aside from being able to grasp the meaning of the term "energy problem," which is heard almost daily, the rationale for developing these interdisciplinary materials is to provide teachers and students with an understanding of the role and importance played by energy in our daily lives.

Limited Energy Resources. The world's supply of natural resources, especially those which go into the production of energy, is finite. The geological forces which create these natural resources operate so slowly that they can be considered non-renewable. These energy producing resources are being used at ever increasing rates by affluent nations of the world. Until recently little thought or attention had been given to what will happen when these much needed raw materials become scarce or ultimately depleted.

Increased Energy Use. This rapidly expanding use of the earth's natural wealth is particularly significant in North America where one-sixth of the world's population lives. This fraction of the earth's population consumes one-third of the earth's annual output of natural resources to produce the goods and services represented by our present-day standard of living. This high standard of living is highly dependent upon available energy and has made us a very energy intensive society.

Environmental Problems. The increased production of goods and services resulting in the increased use of natural resources has created many environmental problems. Solid waste disposal

problems, waste heat, and potential radioactive waste dangers are just some of the many environmental problems which our energy intensive society must face and resolve if we are to maintain our present standards of living.

Political and Economic Problems. To compound the problems already noted, the less affluent people of the world aspire to the same economic and social levels currently enjoyed by most western countries. However, experts tell us that there are not enough natural resources to support everyone in the world at the same level of affluence. This creates many political and economic problems for the so-called underdeveloped countries as well as for the developed nations. It is not surprising, therefore, that the prices charged by the underdeveloped countries for their natural resources and raw materials are increasing steadily and that these price increases have a direct bearing on our life style.

Natural Resources. It has been said that "the world has ample natural resources and that we need only new technologies to exploit this wealth." This reliance upon a "technological fix" to solve our problems is very shortsighted. One point that is neglected in this argument is that it requires energy and raw materials to produce end products and usable energy. The traditional sources of energy are becoming scarce because they are created from limited natural resources. In addition, raw materials are not found in unlimited quantities.

A New Energy Ethic. An awareness of the problem we have mentioned brings us to a final point. We cannot continue our present patterns of increasing consumption of raw materials and energy. We

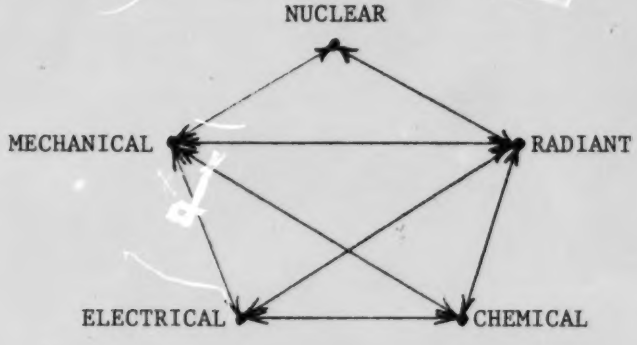
must adopt a new energy ethic and become seriously concerned with conservation of our natural resources. Long-range planning for multiple alternative long-lived energy sources is needed if we are to maintain both the quality of the environment and life itself. We are indeed passengers upon "Spaceship Earth" and we must become vitally concerned for both that spaceship and its passengers.

CHAPTER IV

DEFINITION OF ENERGY

Energy is the ability to do work.

Energy is found in many forms and may, in fact, be transformed in many cases, as is indicated by the arrows in the diagram.



The many and varied forms of energy can become confusing, hence to facilitate communication, the scientist generally thinks of energy being in one of the following classes.

Mechanical--the energy of motion; falling, rolling or sliding bodies, sound, etc.

Electrical--The energy composed of electrons; either the push or pull between bodies that are electrically charged and/or have a magnetic field about them; or the changes which result from the movement of electrons (friction, etc.).

Radiant --the energy of wave phenomena resulting from the acceleration of a charged particle; x-ray, heat, light, etc.

Chemical --the energy released or used up during an interaction between the electrons of various atoms (in chemical

reactions); corrosion, fire, explosion, biological, etc.

Nuclear --the energy released or used up during alterations within the nucleus of atoms; fission, fusion, transmutation.

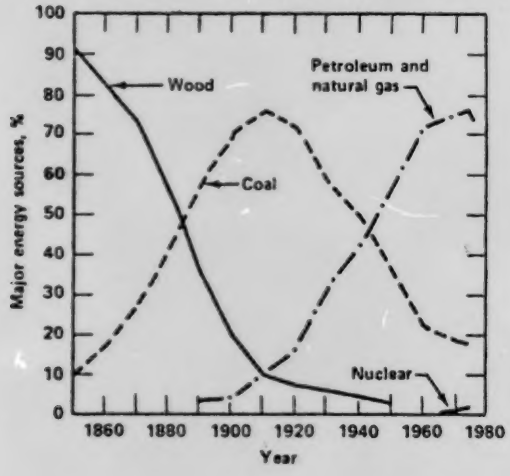
Energy, regardless of its form, may or may not be active at any one time, therefore, each of the classes above may be divided into potential (stationary) or kinetic (moving).

CHAPTER V

THE ENERGY PROBLEM

The United States, which uses one-third of the world's total energy consumption, relies most on its scarce domestic energy resources and least on its abundant ones. The Nation has an energy problem because three-fourths of its energy comes from oil and gas. Coal, our most plentiful fossil fuel, currently supplies less than 20 percent of our energy needs. Uranium, which has a domestic energy potential even larger than coal, provides only 2 percent of our energy. The contribution of solar energy is negligible.

HISTORICAL U.S.
ENERGY CONSUMPTION PATTERNS

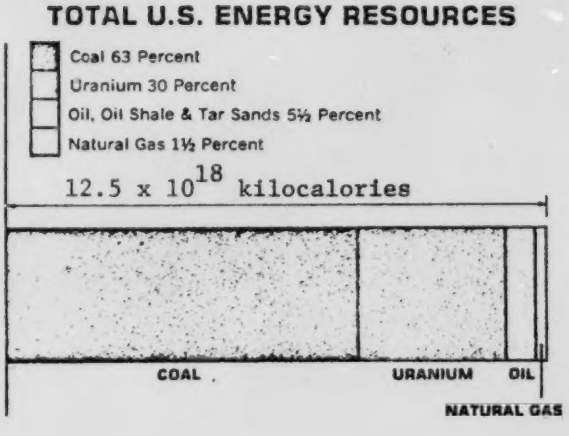


U.S. Energy Resources

The U.S. Geological Survey informs us that our energy resources inventory totals 50 quintillion BTUs (12.5×10^{18} kilocalories). The Nation's energy supplies are defined as. . .

Energy Resources--discovered and yet undiscovered deposits judged likely to be found, including submarginal deposits which would require new technology and higher prices for recovery.

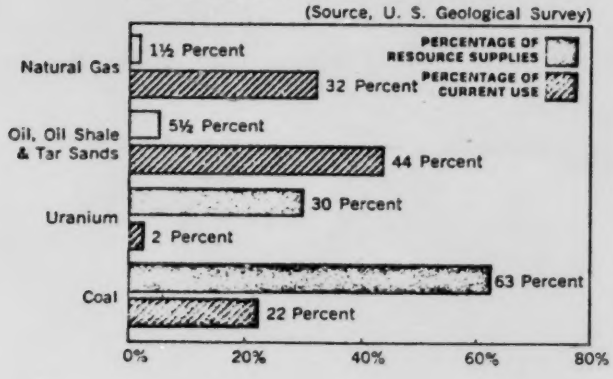
Energy Reserves --deposits that are economically recoverable with today's technology.



As the graph on the following page indicates, resource supplies and the current rate of energy resource consumption is completely out of balance.

TOTAL U.S. ENERGY RESOURCES COMPARED TO CURRENT USE

(Source, U. S. Geological Survey)



PRIMARY ENERGY USE BY REGIONS

millions of barrels daily
(oil equivalent)

		0 2 4 6 8 10 12
OIL		
	East Coast	XXXXXXXXXXXXXXXX///////////////
	North Central	XXXXXXXXXX////////
	Gulf Coast	XXXXXX//////////
	Rocky Mountain	X//
	West Coast	XXXXX//////
NATURAL GAS		
	East Coast	XXXXX//
	North Central	XXXXXXXXX/
	Gulf Coast	XXXXXXXX////
	Rocky Mountain	XX
	West Coast	XXXXX///
COAL		
	East Coast	XXXXXX//
	North Central	XXXXXXXXX//////
	Gulf Coast	XX//
	Rocky Mountain	X//
	West Coast	X/
WATER POWER		
	East Coast	X/
	North Central	X/
	Gulf Coast	X/
	Rocky Mountain	X/
	West Coast	XX//
NUCLEAR		
	East Coast	X////////
	North Central	X/////
	Gulf Coast	////
	Rocky Mountain	/
	West Coast	X///

Total Use to 1970 XXXXXX Projected Use to 1985 //////

Courtesy of The Chase Manhattan Bank

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CHAPTER VI

SELECTED FORMS OF ENERGY USED BY MAN

Coal

Overview

Following three decades of relative stagnation, the U.S. coal industry is entering a new era of growth. Changing worldwide economic and energy supply conditions have made coal a more competitive and secure fuel source, thereby creating the driving force for increased investment and expansion in the coal industry. Government actions, to date, have acted to limit the expansion of domestic production of all fuels including coal, however, the momentum of free economic forces caused U.S. coal production to reach a 25 year high in 1975 with a new record year in sight for 1976.

As most current references are quick to point out, the nation's capability to derive increased energy supplies from coal is not a problem of resources or discovery. The United States has abundant domestic coal reserves, however, the large capital, labor, transportation and cleanup technology requirements will bear heavily on the future economic use of coal and on coal's ability to replace petroleum fuels in the marketplace.

Prepared by Energy Resource Industry Committee for Oklahoma Energy Awareness and Conservation Month, November 1976.

Resources

The estimated remaining mapped coal resources of the United States as of January 1, 1972, were 1.6 trillion tons.[1] There is an additional 1.6 trillion tons of estimated hypothetical resources, bringing the total U.S. coal resource base to 3.2 trillion tons as estimated by the U.S. Geological Survey.[2]

The U.S. Bureau of Mines estimates total remaining strippable reserves at 118 billion tons, mostly in the western states, and eastern underground reserves at approximately 162 billion tons.[3] Current references estimate remaining domestic coal reserves available to conventional mining systems at about 400 billion tons, with one-half to two-thirds of this quantity recoverable.[4] Conservatively speaking, the U.S. has sufficient economically recoverable reserves for over fifty years of coal supply remaining and, in addition, a very large resource base available to improved coal recovery technologies.

There are 7.2 billion tons of mapped coal resources remaining in Oklahoma.[5] However, a large percentage of Oklahoma's coal resource base is in thin underground beds which are currently subeconomic.

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[1]Reference USGS: Includes beds of bituminous coal and anthracite 14 in. thick or greater and beds of subbituminous and lignite 2½ ft. or more thick. This estimate includes all coal seams to a depth of 3000 ft.

[2]USGS

[3]USBM IC. 8531 & 8680

[4]Federal Energy Administration, National Petroleum Council

[5]S. A. Friedman's report to the Ozarks Regional Commission, July 10, 1974.

Production

Bituminous coal production set a near term record in 1975 at 640 million tons. This is up from 590 million tons in 1973 and 600 million tons in 1974. The ten year growth rate (1966-1975) of U.S. coal production has been less than 2 percent, however, production grew by 6½ percent in 1975 and is forecast to increase 8-10 percent in 1976 with this year's production close to 700 million tons.[6]

The Keystone survey[7] of new coal capacity additions reports a total of 535 million tons of new mine capacity now planned or under construction and scheduled for production by 1985. Fifty-seven percent of the planned capacity additions are from 64 surface mines and 43 percent of the additions are from 177 deep underground mines. Assuming these expansions progress as scheduled, 1985 coal production should exceed one billion tons. There are no major new mining projects in Oklahoma listed, although a substantial number of small surface mines have commenced production over the past several years. In January of 1976, there were 31 coal mines in operation in Oklahoma as compared to eight mines producing in 1973.

Demand

Market forces continue to be the key determinant in the rate of domestic coal development. The inter-fuel competitive position of coal is currently the best in recent history. Increased natural

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[6] Coal Age Annual Review. February, 1976.

[7] 1976 Keystone Coal Industry Manual.

gas, fuel oil, and nuclear energy costs; restriction on the use of natural gas and oil as boiler fuels; delays in construction and licensing of nuclear plants; and an expanding economy, have placed increased market demand on coal.

The bulk of coal demand is for electricity production. 1975 coal consumption as reported by the Bureau of Mines by consuming sector is as follows:

1975 Coal Consumption
(millions of tons)

Utilities	404	65%
Steel	85	14%
Industrial	65	10%
Retail	8	1%
Export	66	10%
TOTAL	628	100%

Almost 80 percent of the projected coal production capacity expansions are directed at the steam coal market.

Electrical World's most recent electrical power growth forecast projects an additional 125,000 megawatts of fossil steam capacity by 1985.[8] Assuming this is coal-fired capacity, an additional 300-350 million tons annually of utility coal will be required to fuel these plants by 1985. Steel industry demand for coal is not expected to grow at the rate of utility demand, however, industrial coal use should increase and export markets remain strong.

Coal Leasing

A revised program of federal coal leasing is expected to be initiated within the next two years. Nominations of land for coal

[8]Electrical World, September 15, 1976--27th Annual Electrical Industry Forecast.

leasing have been received by the Department of Interior and are currently under review. According to announced plans, the evaluation process should continue for approximately 18 months before new federal lease sales are held.

Although there are large undeveloped coal reserves in the United States, a major share of the most economical remaining reserves are in lands controlled by the federal government, therefore, a renewed federal leasing program is essential to the long term development of domestic coal resources in an economically optimum sequence and to the long range planning of new electrical capacity.

Transportation

The scheduled expansion of western surface mining currently estimated at approximately 200 million tons per year will create additional demand on the western railroads. Except for some possible temporary delays in the installation of new track, it is expected that the existing rail system can accommodate the increased coal traffic.

The possibility of a coal slurry pipeline as an alternative to rail transportation has been discussed, and some projections show a coal slurry pipeline system to be economical; however, this proposal continues under discussion and there are no firm plans for a slurry pipeline at this time.

Employment

Bureau of Labor Statistics report total employment in the coal mining industry to be 216,000. This work force supplies

approximately 17 percent of primary energy consumption in the United States.[9] For comparison, the oil and gas production, oil field services and petroleum refining industry employs approximately 500,000 in the United States and produces approximately 55 percent of domestic energy consumption.

Capital Requirements

Coal industry capital requirements are expected to increase significantly over the next ten years. Recent projections range between $18 and $23 billion (1975 dollars) for coal industry capital investment over the period 1976 through 1985. For comparison, capital spending over the previous ten year period was $6.5 billion. The coal industry's capital requirement is less than 10 percent of projected petroleum industry capital needs and is not expected to curtail expansion provided the economic incentives for coal development continue.

Environmental Restraints

Perhaps the key restraining forces on the future rate of coal development and utilization hinge on questions concerning governmental permission to mine coal and restrictions on its use. Strict controls on surface mining and SO_2 emissions from stack gases have importantly impacted the cost of coal as a utility fuel and more stringent regulations are under consideration. The most recent environmental concern related to the burning of fossil fuel is the possible impact on climatic conditions of accumulated CO_2. Public

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[9] FEA Monthly Energy Review, April, 1976.

policy in the environmental area has substantially altered the timing and cost of coal production in recent years and will continue to be one of the principal controlling factors on coal utilization in the future.

Advanced Processing Technology

Under current cost and market conditions, the increased use of coal is dependent on its conversion to electrical energy. In order to use coal directly as a replacement fuel for oil and gas, a great deal of emphasis is being placed on coal liquefaction and gasification technology with a number of demonstration projects being conducted with government sponsorship. The expected cost of liquid and gaseous fuels from coal is above controlled oil and gas prices, therefore, an unsubsidized commercial coal refining industry is not yet viable. Major utilization of coal for gasification and liquefaction is not currently expected before 1990, however, a further increase in the relative price of oil and gas could change this outlook.

The direct use of solid coal in transportation, residential, and commercial applications is beginning to receive new attention and represents a potential area of technological breakthrough.

Geothermal Energy

Geothermal energy, the heat deep inside the earth, is a vast potential source of useful power which should become available for a wide variety of important applications as economic exploitation technologies are developed. This internal energy of the earth is thought to be the result of the natural decay of radioactive materials. Thus it is virtually inexhaustible, although the heat content of a particular reservoir might be depleted after several decades of active use.

Theoretically, such energy could be obtained at any point on earth by drilling deeply enough and providing some arrangement for extracting the heat. In most parts of the world the hot interior mass is too deep to reach with existing drilling technology, but in some areas, including many places in the western U.S., large heat sources occur close to the surface. The exact locations and sizes of these sources are not yet completely established.

There are several basic types of geothermal energy reservoirs; dry steam, hot water, hot dry rock, geopressured water, the normal thermal gradient in the earth's crust, and magma.

In the United States, the use of dry steam for electricity generation has been the major economic application. Hot water--with and without steam--has also been employed, but largely for heating purposes, and only in a very few locations. Its application to power generation is now being seriously proposed. Hot dry rock, which is thought to be the largest heat resource, has not been tapped, but several new methods of heat extraction are being actively pursued.

Historically, the commercial application of geothermal energy for generating electricity dates back to 1904 in Italy. Today, power is being produced from geothermal sources in Iceland, Italy, Japan, Mexico, New Zealand, the Soviet Union, Turkey, and the United States.

In the U.S., the major geothermal power plants are located at a natural steam field in Northern California known as The Geysers. Here, steam is collected from a number of wells, filtered, and passed through turbines that drive electric generators. This type of geothermal installation costs less to build than a conventional steam plant of the same capacity, even though the lower pressures and temperatures of the steam at The Geysers plants make the fraction of the available heat that is converted to electrical energy less than that achieved by fossil or nuclear steam electric power plants.

It is significant that the utilization of natural steam, as illustrated by the electrical plants at The Geysers, is fully developed commercially, and the overall cost of the power is less than that generated by fossil or nuclear plants. The technology is limited in its application, however, because additional large dry steam fields are not now known and are not believed likely to exist in the United States. The only apparent exception is in Yellowstone National Park, where commercial development is prohibited.

Hot Water Wells

The geothermal wells in The Geysers region of California, and at Larderello in Italy, produce dry steam free of water. It is more common for geothermal wells to yield a mixture of steam and

hot water. The steam is produced because a portion of the hot water spontaneously boils as it rushes freely to the surface.

This combination is less useful than dry steam, since greater quantities of fluid must be produced by the well for a given plant generating capacity, and more water must, therefore, be disposed of, usually by reinjection into the earth.

In many places in the western U.S., there are hydrothermal wells that produce hot water without steam. Only limited use has been made of these resources. In one proposed method of harnessing this energy, called the "Binary Cycle," the hot water is passed under pressure through a heat exchanger, where it causes the vaporization of liquid with a lower boiling point, such as Isobutane or Freon, that is contained in a sealed secondary system. This vapor expands through a turbine that drives an electric generator. The original geothermal well water, which would be kept under pressure and not permitted to boil, would be reinjected into the ground.

Another promising idea is intended for application to the hot waters of the Salton Sea area of Southern California, which contain heavy concentrations of minerals.

The basic idea is called the "total flow" concept. The object is to convert some of the thermal energy of a pressurized-steam, hot water mixture into kinetic energy by forcing it through a converging-diverging nozzle. The resulting high velocity jet output would be used to drive a modified hydraulic impulse turbine. Theoretically, this method should produce 60 percent more power than other systems, operational or proposed, for this type of application. The advantage is that the total flow is used, and

this allows recovery of some energy in the liquid that would otherwise be lost.

Hot Dry Rock

The principal practical uses of geothermal energy have been associated in the past with naturally occurring steam (or a mixture of steam and hot water) but the evidence suggests that perhaps the largest potential geothermal energy resource is hot rock that has not come into contact with underground water systems.

One promising method being studied would employ the hydrofracturing technique used in petroleum recovery. In this scheme, high pressure water would be used to create a large crack in hot rock, such as granite, which overlies an area of high heat flow from the earth's interior. Pressurized water would then be forced through the crack to extract the heat.

There are uncertainties in this approach. For example, it is not known whether the various hot rock formations would be sufficiently impermeable to keep the pressurized water from leaking away. Hot rock will contract as it cools so that the initial cracks may be extended to make new hot rock available for extraction of additional heat. Considerable experimental work is needed in order to learn how a rock such as granite will behave under various conditions of high temperature and pressure.

Another method of extracting heat from hot dry rock is to use explosives instead of hydrofracture to increase the surface area for water contact. Both methods--explosive and hydrofracturing--require extensive research programs to provide necessary data.

Geopressured Water

Geopressured resources are known to occur along the Texas and Louisiana gulf coasts. Unlike other geothermal areas, the energy potential of the waters in the geopressured areas are not limited to thermal energy. The extremely high fluid pressures of these hot waters are a potential source of mechanical (hydraulic) energy. In addition, dissolved natural gas, primarily methane, contributes significantly to their energy potential. Because of petroleum drilling in the gulf area, abundant subsurface information is available.

Normal Thermal Gradient

There is useful, but low-temperature, geothermal heat at some depth under all regions of the country. The closer one approaches the center of the earth, the hotter it becomes, and this is the normal thermal gradient. Economic recovery and use of this low quality energy hinges on significant improvements in drilling technology and energy extraction methods. Recovery of resources at the normal gradient is a long-term issue whose resolution could contribute significantly to U.S. energy supplies.

Magma

Magma is the very hot liquid, or partly liquid, rock that is found under the entire surface of the earth, starting at depths of 6 to 30 miles (10-48 kilometers). These depths are too great for economic utilization. However, in some places the magma exists close to, or even at, the earth's surface--at times in large volumes. No techniques are yet known for converting this energy

into useful forms for commercial exploitation. Beneficial use of magma heat is expected to require another long-term research and development program.

Environmental Effects

Putting geothermal energy to work has many advantages from an environmental standpoint. An important one is that almost all the activities related to the production of geothermal power are in the immediate vicinity of the plant. The kind of distant support operations required for fossil or nuclear plants, such as mining, fuel processing, transportation, storage, and other handling activities are not involved. On the negative side, there are certain undesirable environmental effects that could extend for some distance from a geothermal plant location and these must be carefully controlled to preserve environmental values.

For example, the proper disposal of waste water from steam or hot water wells can become an important problem, particularly when the water has a substantial mineral content. Gaseous discharge may also be a significant factor, because of the noxious gases such as hydrogen sulfide that are produced by some geothermal wells. Other difficulties include waste heat disposal and the atmospheric effects of cooling towers, which are similar to those experienced by fossil or nuclear generating plants. There are also questions that relate to seismic effects and subsidence of land surfaces. On balance, however, the environmental problems raised by the use of geothermal energy are probably not as serious as those connected with fossil or nuclear steam plants.

The contained heat energy beneath the United States could, in theory, provide all the future needs of this Nation. Yet a modest goal of 7,500-15,000 megawatts (2 percent of the U.S. total) is the anticipated geothermal contribution by 1985.

Hydroelectric Energy

Water at some height above its surroundings possesses gravitational potential energy. If it is allowed to fall from this height, its potential energy is converted to kinetic energy which can drive a turbine generator combination to produce electric energy. Promising hydroelectric sources are naturally associated with large rivers, canyons or other places where water can be made to form lakes behind high dams.

Natural Gas

Natural gas, like coal and oil, is a fossil fuel. A mixture of gases, it is composed mostly of methane, an odorless, colorless, and tasteless gas that is lighter than air. A distinctive odorant is added to natural gas so that people recognize its presence. Conditions similar to those which produce oil also produce natural gas, and they are often, but not always, found together.

Natural gas and oil were formed, it is believed, out of the tiny plants and animals that existed on the land and in the water that covered much of the earth hundreds of millions of years ago. Gradually, the remains of these plants and animals were buried in layer upon layer of sand, mud, and other sediment. Time passed and the pressure, heat, and, perhaps, the action of bacteria and radioactivity changed these remains into oil and natural gas, which

collected in layers of porous rock. Gas can move more easily through the porous rock than can oil and, as a result, there are many areas of natural gas not associated with oil.

Nuclear Energy

Fisson

Nuclear energy is a method of generating electricity. Like most methods of generating electricity, a fuel is burned to produce heat, the heat makes steam, and the steam drives a turbine to make electricity.

The only difference between nuclear power plants and conventional power plants is the fuel. Conventional plants burn fossil fuels--natural gas, oil, or coal. The nuclear fuel most commonly used today is uranium-235, which occurs in nature. A man-made element, plutonium-239, can also be used as fuel. In a nuclear reactor, the fuel atoms fission, that is, they split apart, and this process releases tremendous quantities of heat to make electricity.

Our uranium supplies contain a tremendous energy potential--a piece of uranium fuel the size of a golf ball has the energy equivalent of 168,000 gallons (636×10^3 liters) of oil.

In 1975, nuclear plants produced electricity for a total cost that was 63 percent less than that for oil plants and 30 percent less than that for coal plants; this saved consumers over $2 billion on their utility bills. If all costs are included (such as construction, operation, maintenance, and disposal of wastes) nuclear plants are more economical than fossil fuel plants.

With the addition of the 156 reactors now being built or planned, the electricity generated from nuclear power in 10 years

will be the equivalent of 5 million barrels (8×10^8 liters) of oil every day. That's almost as much oil as we currently import. As of April 1976, 59 power reactors were operating in this country and were supplying more than 9 percent of our electricity.

One common question asked about nuclear power is: Is it safe? One only need examine the nuclear safety record of the industry: With over 175 commercial and 1300 naval reactor-years of operation, no member of the public has ever been injured or killed by a nuclear power plant.

The approach to assuring reactor safety has three levels.

First, the reactor is designed, built, and operated so as to be inherently safe and to accommodate abnormal conditions should they occur.

Second, there are independent backup systems to assure that, if an incident should occur, the reactor would be shut down with no adverse effect.

And third, hypothetical accidents are examined--even though the probability of one occurring is extremely remote--to assure that public health and safety is maintained even under these severe conditions.

In considering reactor safety, there are several points not widely recognized. One is that a nuclear plant cannot explode like a bomb. It is a physical impossibility. The necessary conditions simply do not exist.

Nuclear plants are among the cleanest and most environmentally acceptable of all methods of energy production. In terms of land use--including the reactor, the land used in mining the fuel, and

the land required to dispose of the wastes--nuclear plants require the smallest acreage of all power plants. Another advantage is that they do not emit chemical pollutants into the atmosphere.

In terms of the waste heat ejected into the environment (thermal pollution), nuclear plants release slightly more than modern fossil plants. Careful environmental studies are done in the vicinity of nuclear plants, and if the heat ejected into bodies of water is harmful to aquatic life, cooling towers are built to release the heat directly into the atmosphere, thus eliminating the problem.

Nuclear plants routinely release very small amounts of radioactivity. Everyone receives radiation from sources such as the sun, rocks, and soil. We all receive about 50,000 times more radiation from this "natural background" than from a nuclear plant. In fact, many of the things we do--such as watching color TV, receiving an X-ray, or traveling by plane--expose us to significantly more radiation than do nuclear plants. Care is taken through plant design features and precise monitoring equipment to assure that the radioactive releases from nuclear plants remain negligible. The following table shows total average radiation exposure from various sources.

AVERAGE ANNUAL RADIATION DOSES (IN MILLIREMS)

Natural	
Sun, rocks, soil, ...	130
Man-made	
Medical diagnosis	72
Fallout from past nuclear weapons testing	4
Television	0.1
Commercial products	1.9
Air Transport	1.3
Commercial nuclear power	0.003
TOTAL	209.303

One concern about nuclear power is the management of the radioactive wastes produced during reactor operation. Most of the wastes are not highly radioactive and can be disposed of routinely in commercial burial grounds. But a small amount of the waste will remain radioactive for thousands of years, and therefore must be disposed of permanently. Dealing with these high-level wastes is not a new problem. As a result of the military weapons program and other federal programs, high-level wastes have been in existence for 30 years, and have been stored in liquid form with no harm to the public.

One requirement for high-level liquid wastes from reactor operation is that they must be solidified; in this form, they are immobile and can be stored safely for as long as necessary. The technology already exists to permanently dispose of these wastes, and concepts are now being studied to select the best methods.

The most promising concept is deep burial in a stable geologic formation such as salt or granite. Fortunately, the volume of waste will be so small that a minimal amount of land will be required.

Another concern about nuclear power is that facilities might be sabotaged or that nuclear materials might be stolen and released to the environment or used to fabricate weapons. Certainly a safeguards system that assures the continual protection of nuclear materials is essential, and we have had 30 years of successful experience to date.

Today very strict measures are in effect to safeguard these materials by physical security, monitoring, accounting, and inven-

tory control.

The danger of theft in transporting nuclear materials might ultimately be eliminated by locating fuel processing and fabrication facilities at one site.

Certainly it is clear that along with increasing our use of coal, we will have to increase our use of uranium to meet our energy needs in the near term. If we continue to build predominantly light-water reactors, which are the kind of nuclear reactors operating today, our known high-grade reserves will last less than 50 years. The reason for this is that light-water reactors can only efficiently use uranium-235, an isotope that constitutes less than 1 percent of naturally occurring uranium.

For over 25 years, an advanced nuclear reactor called the liquid metal fast breeder reactor has been under development. In fact, the first electricity produced by nuclear power was from a reactor of this type--the Experimental Breeder Reactor 1--in Idaho in 1951. This type of reactor is called a breeder because it actually creates more fuel than it uses.

While it produces electricity, it converts the abundant non-fuel uranium-238 (the remaining 99+ percent of natural uranium) into the usable fuel, plutonium. A breeder can tap almost 60 times more of the energy in uranium than a light-water reactor can. Thus, it would allow us to use our uranium reserves more efficiently. With the breeder our uranium reserves would last for centuries rather than decades. And breeders would also make the cost of electricity relatively insensitive to increases in the price of fuel. With breeders, one can envision relatively stable, economical power costs.

The Experimental Breeder Reactor II in Idaho is currently the only operating reactor of this type in the U.S.; it is now in its 12th year of successful operation. Primarily a test reactor, it has been producing electricity reliably during this period and continues to do so. France, England, and Russia already have large breeder plants in operation. In Richland, Washington, the Fast Flux Test Facility (FFTF), the largest breeder test reactor in the world, is scheduled for completion in 1978.

It is expected that with a successful development program, reactors of this type can be producing power commercially by the 1990s. With light-water reactors and then breeders, we will be assured of safe, clean, reliable, and economical nuclear power to meet the energy needs of this country well beyond the foreseeable future.

Fusion

The process of combining (fusing the nuclei of light elements to produce large quantities of heat energy is called fusion; it is the process by which the sun and other stars generate their energy. Fusion reactions have been demonstrated in the laboratory for very short periods of time, but not in the sustained fashion required for power plant operation. Despite the difficulties of applying the fusion principle, its importance is so great that many substantial research efforts are under way all over the world. Its most important feature is that its fuel is derived from water, and the water in the oceans would supply large amounts of energy for millions of years. It is estimated that commercial fusion application will begin at about the end of this century.

Oil Shale

A tremendous amount of virtually untapped oil is locked in rock called oil shale.

Oil shale is a very fine grained sedimentary rock, containing enough organic matter (hydrocarbon) to yield at least 10 gallons of oil per ton (42 liters per metric ton) when properly processed. Some shales yield much more oil, however, and in the United States some thin layers have been reported to yield 140 gallons of oil per ton (583 liters per metric ton). Most shales of commercial interest yield from 25 to 65 gallons of oil per ton (104 to 271 liters per metric ton), though some foreign deposits yielding between 10 and 25 gallons per ton (42 and 104 liters per metric ton) have been mined on a large scale. Many other organic-rich shales yield less oil, from 1 to 10 gallons per ton (4.2 to 42 liters per metric ton), but these shales are so low grade that they usually are not called oil shale.

The combustible portion of oil shale is mostly solid organic matter composed of carbon, hydrogen, oxygen, and usually small amounts of nitrogen and sulphur. Some oil shales contain substantial amounts of bitumen (incombustible asphalt-like material) intimately mixed with solid organic matter. Other noncombustible minerals such as calcite, dolomite, clay, quartz, and feldspar generally make up more than half the rock.

Most oil shale is dark (black, brown, or dark gray), but some layers are colored yellow, red, or green by waxy organic materials. By viewing very thin slices of these rocks through a microscope, one may see small mineral grains surrounded by dark shapeless masses

of organic matter speckled with brilliant yellow, red, or green particles. These particles are probably fossil remains of spores, pollen, or filaments or algae, a single-celled plant. The remains of other plants or animals may also be conspicuous, though the organic matter is generally so finely pulverized that the fossils cannot be recognized.

When shale is heated in a retort to a temperature of about 900°F (482°C), some of the organic material melts, and when this liquid is heated to higher temperatures, gases form. The vapors can be condensed to form oil, with part remaining as hydrocarbon gas. From 25 to 75 percent of the organic matter in oil shale can be converted to oil and combustible gas. The remaining carbon forms combustible char or coke.

Oil shale accumulated as layers of organic ooze and mud on the bottoms of ancient lakes, ponds, lagoons, and shallow seas--places where plant or animal life was abundant. As organisms died and sank to the bottom, their remains were partly preserved--particularly where the water was stagnant and lacked sufficient oxygen for complete decay of organic matter. The organic-rich layers of mud were gradually buried as younger sediments accumulated above them, and the weight of the overlying material slowly turned the mud into hard shale. The unusual conditions associated with the accumulation and preservation of the higher grade oil shales are largely unknown. Earth scientists, including geologists, geochemists, and geophysicists of the U.S. Geological Survey, are studying the organic material, the chemical and physical environments, and the mineral composition of ancient and modern lake deposits to learn more about

the natural processes that produced oil shale.

Petroleum

Generation of Petroleum

Petroleum is a complex mixture that consists mainly of molecules of hydrogen and carbon (hydrocarbons) but that also contains minor amounts of non-hydrocarbons. Material from previously existing organisms (organic material) is converted to petroleum under the influence of earth temperatures and time--much time, measured in millions of years. After petroleum is formed, deeper burial and subsequent pressures cause it to migrate to underground reservoirs where, under suitable geologic conditions, it becomes concentrated in the pores and fractures of certain rock types, such as sandstone, limestone, and dolomite. Thus the generation of petroleum is a complex geologic process, requiring several million to hundreds of millions of years. Clearly, then, petroleum is a non-renewable resource.

When underground accumulations are drilled and yield petroleum in sufficient quantities, these are considered producing fields. Proved reserves are the estimated quantities of petroleum that can be taken from known reservoirs under current economic conditions.

Although the conditions required for the generation of petroleum are somewhat specific, the preservation of petroleum generated millions of years ago requires conditions that are even more rigid. Indeed, the conditions related to origin, migration, and entrapment must have occurred in a specific sequence in order to make a particular petroleum deposit applicable as a current energy source. These

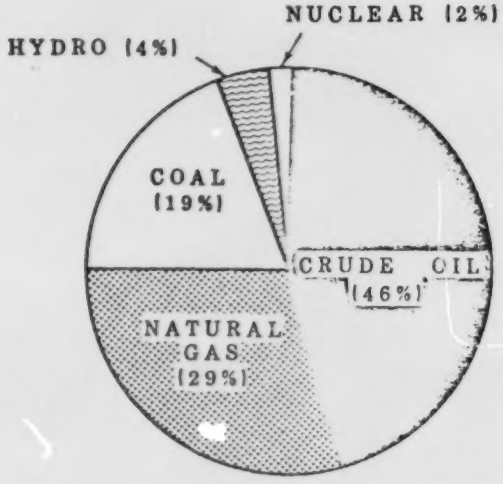
conditions are fulfilled so rarely that exploration for additional petroleum reserves has become an increasingly high-risk undertaking.

Crude oil is a petroleum mixture that is in liquid form at the earth's surface, although it may exist in either a liquid or a gaseous state underground.

Natural gas is a petroleum mixture that remains in a gaseous state at the surface.

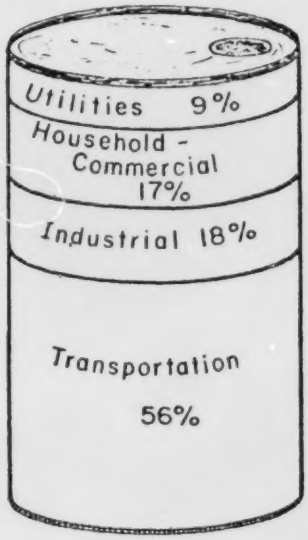
Energy from Petroleum

As indicated in the diagram below, petroleum furnishes some 75 percent of our nation's current energy needs. The fossil fuels (petroleum and coal) supply 94 percent of our total energy requirements, with hydropower contributing 4 percent and nuclear power contributing a mere 2 percent.



National consumption of energy by sources.

If a barrel of crude oil were converted directly into heat (BTU's), there would be enough energy to heat the average Oklahoma house for 11 days during the middle of the winter. Normally, crude oil is not used by consumers directly but goes through several processing steps. The figure to the right shows how a typical barrel of crude oil is used. By contrast, natural gas is used mainly for industrial and household purposes (81 percent); the remaining 19 percent is used mostly for generation of electricity, with a small amount used for transportation.



Solar Energy

Sunshine has either directly or indirectly supplied almost all of man's energy requirements since the beginning of time.

Millions of years ago the sun's rays stimulated the chemical reactions that formed coal, petroleum, and gas--the fossil fuels.

The sun helped to create the wood burned by early man after he discovered fire, the first source of controllable energy and still the most important.

Sunshine is an essential element of the plant and animal life that has provided man's food and much of his transportation.

The sun's heat continuously evaporates some of the earth's waters, which return as rain to feed the streams and rivers. These powered man's early industry in the form of the "old mill stream",

and now operate large hydroelectric plants.

Finally, the sun's interaction with the earth's atmosphere produced the winds that enabled man to explore the world in sailing ships, and for many centuries provided useful power through windmills.

Technically, sunshine consists of electromagnetic waves that travel through space at the speed of 186,000 miles (almost 300,000 kilometers) per second from the sun, which is 93,000,000 miles (almost 150,000,000 kilometers) from the earth.

Sunlight arriving at the edge of the earth's air space carries energy at a constant rate of 444 British Thermal Units (BTU) per hour (111 kilocalories per hour) for every square foot (1,195 kilocalories per square meter per hour) of area. (In electrical terms this is equivalent to 130 watts.) Taking into account absorption by the atmosphere, hours of darkness, cloud cover, and geographical location, the *average* amount falling on a square foot (or square meter) of ground in the U.S. on a yearly basis is about 13 percent of this or 58 BTU's (14.5 kilocalories) per hour (155.4 kilocalories per square meter per hour) (17 watts in power units). This amount of heat, if absorbed and retained by a little less than a cubic foot of water would raise the temperature of the water by 1^{o} Fahrenheit during one hour's time (or $.155^{o}$C temperature increase in one cubic meter of water in one hour).

But averages can be misleading, and this is the reason the word average is in italics above. For example, in the summer, there is seven times as much solar energy reaching the gound as compared with a typical cloudy day in winter. And of course there is no

solar energy at all during the night. This intermittent characteristic of solar energy is one of the challenges that must be met in order to efficiently utilize the sun's energy. The storage of energy during these periods of energy demand might be accomplished in a variety of ways, which might include electric storage batteries, pumped water storage, or thermal storage.

The existence of a large amount of heat energy does not automatically mean that it can be efficiently put to work.

Like water flowing from a higher to a lower level, heat must flow from a higher to a lower temperature to be useful. The greater the difference in temperature, the more energy is available for work, just as in the case of water at a higher level behind a dam. These well-known fundamental limitations of heat utilization form a part of the complex science known as thermodynamics.

A fundamental problem with the solar heating of buildings is that the average amount of sunshine tends to be less in those geographical areas that need it most, and at times of the year when heating demands are the greatest. But this circumstance actually works to the advantage of systems designed to utilize solar heat for cooling, which is required more in relatively sunnier sections of the country particularly during the summer months.

Establishing an economically competitive way to store collected solar heat for use at night or during overcast days is a basic problem with solar heating (or cooling) systems. Some of the storage systems that have been used are hot water tanks, bins of rock, and certain substances, such as eutectic salts which are liquified as they absorb heat, and later emit this stored heat as they solidify.

At the present time, all these methods need a conventional backup heating system.

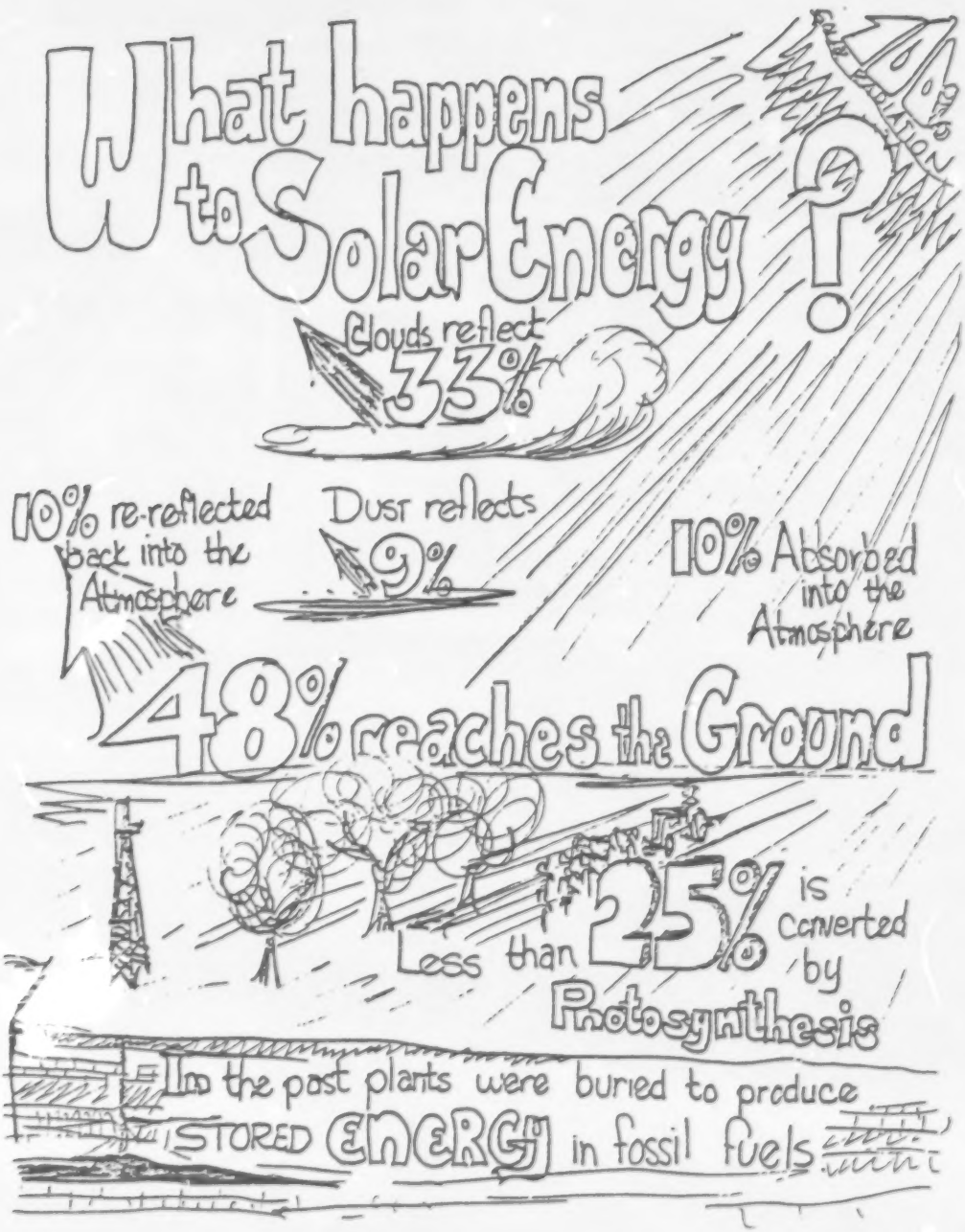
Higher temperatures can of course be obtained by focusing the sun's rays by means of mirrors or lenses. The heat thus produced can then be used in various ways, for example, to operate a turbine. This kind of equipment is more expensive to build and operate than a simple solar heater, and large areas are required to collect the amounts of heat needed for significant practical applications. Accelerated research programs are tackling these problems, however, and solutions should be forthcoming.

The most important applications of solar cells have been in the space program. Space vehicles, and all the various kinds of communications and weather satellites now in orbit, could not be operated in their present form without solar cells to provide electric power directly from the sun.

These cells have not been widely used on earth because they are expensive to manufacture and have relatively low efficiency--about 10 percent from a practical standpoint--with which they convert sunshine to electricity. There are sound reasons for concluding that the maximum possible efficiency is about 25 percent.

Electrochemical storage, which is used in the storage batteries of automobiles and submarines, has many advantages. Although no batteries have been developed that can store sufficient electrical energy in a reasonable space at an affordable cost to meet the requirements of an average household, research is being pursued in a number of batteries and storage areas, and scientists are optimistic about solving these problems.

Another proposed method is to use electricity to generate hydrogen, which would then be stored and distributed as a fuel. The technical aspects of this scheme, usually referred to as the hydrogen economy, are feasible but the capital investments currently required would be unacceptable.


What happens to Solar Energy?
Clouds reflect 33%
10% re-reflected back into the Atmosphere
Dust reflects 9%
10% Absorbed into the Atmosphere
48% reaches the Ground
Less than 25% is converted by Photosynthesis
In the past plants were buried to produce STORED ENERGY in fossil fuels

Tidal Energy

Motion of the moon about the earth produces the ocean tides which rise and fall with a period of about 12 hours. In many locations around the globe, tides are large enough to suggest trapping the water in a bay or other basin at high tide and generating electrical energy by hydroelectric means as the trapped water flows out at low tide.

Wind Energy

Wind power--one of the world's oldest energy systems -is now being reexamined and could begin whistling down the comeback trail in the years ahead. The total amount of wind energy theoretically available is tremendous and inexhaustible.

Since the beginning of recorded history men have used the wind to move ships on the sea and power windmills. For centuries windmills have ground grain into feed and flour and pumped water for irrigation. Wind conversion systems were also generating usable amounts of electricity in Denmark as early as 1910.

Between 1935 and 1955, a number of large experimental machines were built, mostly in Europe, ranging up to about 1,250 electrical kilowatts. While technically feasible, these systems were generally discarded for economic reasons.

The world's largest windmill was the experimental wind turbine generator called the Smith-Putnam machine after its designer and builder. This machine was built in 1941 on a hill called Grandpa's Knob in R··tland, Vermont. This windmill actually generated electricity and fed it into the network of a New England power company.

For 3½ years during World War II it operated off and on for 1,100 hours until serious structural problems caused one of its rotors to fall off and the operating company decided that repairing it would not be economical.

One of the most important current projects is the 100-kilowatt experimental wind turbine generator built for ERDA by the National Aeronautics and Space Administration near Sandusky, Ohio. This propeller-type machine, operating in an annual wind velocity of 14 miles (23.526 kilometers) per hour, could generate enough electricity for 30 average-size homes.

The primary obstacle to using wind energy is its cost compared to other kinds of energy. Research by Government agencies is designed to reduce costs to the point where wind energy would become competitive.

A second problem with wind--as every sailor knows--is that its force is not always available when needed. An important requirement for using wind is the ability to store its energy in the form of electricity or to tie wind generators into a larger electrical network. Breakthroughs in the cost and lifetime of storage batteries--such as marked improvements in high-temperature lithium and sulfur systems, which may result from research would bring us much closer to using wind-generated electricity on a significant scale.

Despite its environmental attractiveness as a non-polluting power source, wind could never satisfy more than a small fraction of the total U.S. energy needs.

Even the largest presently conceived wind turbine could generate only 1 to 5 megawatts. So hundreds of thousands of wind

turbines would be required to produce 20 percent of today's power needs, or 5 percent of what will be needed at the end of the century. Such a large number of wind generators might require an unacceptable amount of land or be rejected by the public for esthetic reasons.

CHAPTER VII

OKLAHOMA AS AN ENERGY PRODUCING STATE

Oklahoma has long been regarded as one of the main energy-producing states in the United States. The State's annual mineral production is now valued at $1.22 billion, nearly 5 percent of the nation's production; the energy fuels alone, including oil, natural gas, natural-gas liquids, and coal, account for $1.13 billion, or nearly 93 percent of the State's annual mineral output.

Oil and Gas

Oil and gas are complex molecules of hydrogen and carbon believed to have formed from the decay of microscopic organisms buried in muddy sediments of ancient seas. Deeper burial later created sufficient pressure to squeeze the oil and gas out of the muds into more porous rocks such as sandstone, limestone, and dolomite. Virtually all of Oklahoma's oil and gas occurs in Paleozoic rocks, with Pennsylvanian and Ordovician formations being the most productive.

No authentic record of the first discovery of oil in Oklahoma is available, but early settlers found oil springs in northeastern Oklahoma and reported a burning spring northeast of McAlester. In 1859, a well drilled for salt near Salina, Mayes County, accidentally produced oil, which was then sold as lamp oil. Of wells drilled in search of petroleum, the first commercial well (one that makes a reasonable profit above the cost of drilling, equipping, and producing) was completed at Bartlesville, Washington County, in about

1896. The earliest recorded production of oil in Oklahoma was 30 barrels (4.8 kiloliters) in the year 1901.

By the end of 1972 more than 293,000 wells had been drilled in Oklahoma in search of oil and gas, and about 82,260 wells were producing. Daily average production of oil per well was 7.7 barrels (1.2 kiloliters). The value of crude oil and natural gas produced during 1972 was $1.11 billion, about 91 percent of the State's total mineral production. Total cumulative production from 1901 through 1972 was 11 billion barrels (1.75×10^9 kiloliters) of oil, 35 trillion cubic feet (almost 1 trillion cubic meters) of natural gas, and 1 billion barrels (1.6×10^8 kiloliters) of natural-gas liquids. Total value of these products was $29.4 billion.

In 1972, Oklahoma established two depth records in the drilling of wells for oil and gas. The deepest well in the world was drilled to a total depth of 30,050 feet (9.16 kilometers) and was plugged back to a shallower depth for completion as a gas well. Another well was completed as a gas well from an interval extending to 24,548 feet (7.5 kilometers), establishing it as the deepest producer in the world. Both of these wells are in Beckham County, in the deep Anadarko basin of western Oklahoma. They were drilled as part of the intensive exploration program designed to find natural-gas reserves known to exist at great depths in major sedimentary basins of the world.

Coal

Large reserves of bituminous coal are distributed over an area of 10,000 square miles (26,000 square kilometers) in eastern Oklahoma.

The coal ranges from low volatile to high volatile. It currently is burned as an energy source in electric-power plants and is converted to coke for use in steel manufacture. More than 200 million tons (1.8×10^{11} kilograms) of coal has been produced from hundreds of Oklahoma mines since mining began in 1872, and a recent estimate indicated remaining reserves of more than 3.2 billion tons (2.9×10^{12} kilograms). Ten Oklahoma companies are currently producing coal at a rate of about 2.5 million tons (2.2×10^{9} kilograms) per year.

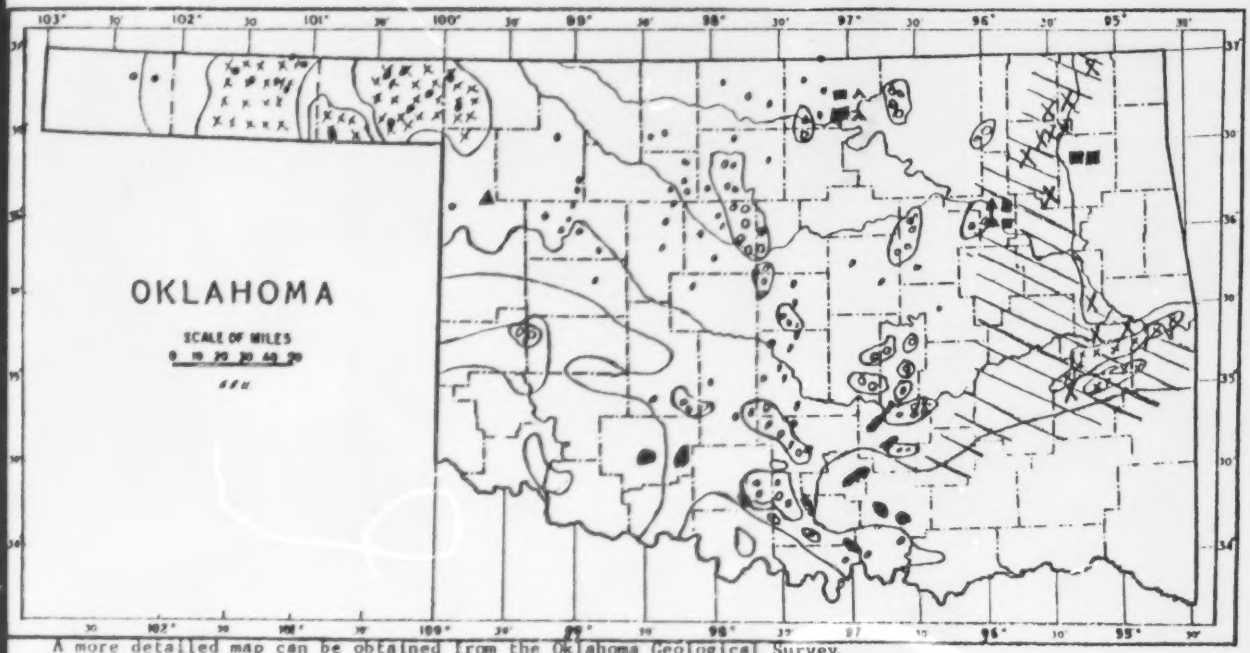
In the past, mined coal lands were left without any serious attempt at restoring or reclaiming the land surface; but restoration is now required by Oklahoma's Mining Lands Reclamation Acts of 1968 and 1971. Newly mined lands must be graded to a gently rolling surface, revegetated, and have their acid-forming minerals buried. In addition, most Oklahoma coal operators voluntarily set aside the original topsoil and then spread it over the leveled "spoil banks". These reclamation requirements greatly reduce one of the major environmental problems that have been associated typically with recovery of this needed energy resource.

Natural Rock Asphalt

Oklahoma has large reserves of natural rock asphalt, which consists of petroleum-impregnated sandstone and limestone. Major deposits occur in the Arbuckle Mountain region, in the southern part of the State. About 3 million tons (2.7×10^{9} kilograms) of material was produced between 1891 and 1960 for use in road construction and maintenance. These rock-asphalt deposits now represent a potential source

of petroleum products that can be developed for energy use at a later time, when technology and economic factors are more favorable for their recovery.

ENERGY-FUELS MAP OF OKLAHOMA



A more detailed map can be obtained from the Oklahoma Geological Survey.

- Area of oil and/or gas production
- Giant oil field
- Giant gas field
- Area of natural-rock-asphalt deposits
- Area underlain by bituminous coal
- Gas-processing plant
- Oil refinery
- Petrochemical plant
- Coal mine

CHAPTER VIII

FUTURE CAPITAL REQUIREMENTS FOR ENERGY

The amount of capital required to meet the Nation's future needs dwarfs all past requirements. Energy recovery and power production, always highly capital-intensive processes, are requiring massive capital expenditures as conventional fuel supplies dwindle. In order to approach past levels of production, energy producers must employ most costly exploration and recovery techniques. In addition, the nation's power companies are in the midst of planning a nearly complete conversion from traditional supply sources to coal and nuclear power.

The capital infusion needed by energy companies and electric utilities over the next ten to fifteen years will require a fundamental shift in traditional capital-allocation patterns in the United States. Oklahoma, being a major consumer and producer and exporter of energy, has a major stake in the ultimate resolution of the energy industry's need for new capital.

How do future capital needs compare to those of the past? Investor-owned utilities had a total capitalization of approximately $40 billion in 1960. In ten years the capitalization had nearly doubled, to $76 billion. By 1980 it is expected to grow another 300 percent--to $235 billion. Last year Continental Illinois National Bank and Trust Company estimated that electric utilities alone would need to raise $500 billion between then and 1985 to pay for new capital investments, assuming an increase in energy demand of 3 to 3½ percent per year.

One of the major energy companies has estimated that the United States will need to invest three to four times as much capital in energy-producing activities over the next ten years as in the preceding ten. The petroleum industry has estimated it will need approximately $400 billion by 1985, and the coal industry around $25 billion. Total capital requirements, excluding debt payments and working capital, add up to around one trillion dollars, of which about one-half will be generated internally and the remainder will have to be raised externally.

In Oklahoma, the increased cost of exploration and recovery is well documented. The average drilling cost per well rose from $75,860 in 1970 to $134,864 in 1974 and costs continue to climb. More ultradeep wells are being drilled, now that domestic energy supplies have failed to keep pace with demand. Their cost, however, is enormous. Gas exploration at 25,000 feet costs ten times as much as does the same exploration at 12,500 feet.

Primary oil production can only recover about one-third of the oil in a reservoir. Enhanced-recovery techniques are increasingly being used to produce the remaining petroleum in our oil fields. In 1976, half of Oklahoma's oil was produced through the use of some form of enhanced-recovery. Over the next five years, approximately 280 new enhanced-recovery projects are planned. These projects and the reworking of existing projects are expected to increase ultimate recoverable oil supplies by 332 million barrels at a capital investment cost exceeding $600 million.

There is little doubt that over the next ten to twenty years a concerted effort must be made to produce oil and natural gas at the

highest efficient rates possible and increase the ultimate recovery of these resources. In the near term, there are no viable alternatives because other fuel sources are not presently available in the quantities or forms required to meet our needs. Oil imports have steadily increased as demand for oil continues to increase and U.S. production continues to decline. By mid-1976, the United States was using about 2 million barrels a day more foreign oil than it did three years previously during the Arab embargo. In fact, during the first six months of 1976, imports of crude oil grew by 33 percent and accounted for 68 percent of all fuels imported during this six-month period. Crude oil imports doubled between 1973 and 1976.

Coal conversion, one means of reducing U.S. dependence of oil and natural gas, is by no means an inexpensive option. It has been estimated that one plant which could convert coal to 100,000 barrels of oil per day would cost about 1 billion dollars! It would take 20 such plants at a cost exceeding $20 billion to fill just the 2 million barrel a day gap that the United States has generated in the past three years!

Converting the nation's electric utilities from natural gas to alternate fuels is both a major technological and financial challenge. Conversion of many utility plants from natural gas to coal is not considered feasible, and in those plants that can be converted, the cost is enormous. Based on OG&E estimates, the cost of converting Oklahoma's existing plants from natural gas to coal would cost approximately $2.7 billion, nearly 10 times the amount of capital spent by Oklahoma's electric utility companies during each of the past three years.

Another way of discussing the capital needed to meet minimal domestic energy requirements is to relate it to gross national product. As a practical matter, two or three percentage points of the GNP must be shifted from some other current use to cover the necessary energy capital outlay.

A secure supply of energy is essential for continued economic prosperity and to maintain the current standard of living. Americans must soon face up to the reality that energy will cost more and that it must have a higher priority in the capital money markets.

Prepared by Energy Resource Industry Committee for Oklahoma Energy Awareness and Conservation Month, November 1976.

CHAPTER IX

ENERGY CONSERVATION IN AGRICULTURE

BY

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Agriculture is deeply concerned with two serious problems facing the world today.

First of all, our current world population of just over four billion may be increased by 50 percent by the year 1995, which also means we will have to come up with corresponding increases in food production. But food production requires energy; and agriculture, from the fertilizer factories to the farm to the dinner table, is highly dependent on non-renewable sources of energy. So, secondly, we must concern ourselves with more efficient use of energy. The priority of food production will keep agriculture high on the list for preferential treatment in times of fuel shortages and allocations. In the spirit of cooperation, farmers must show good faith and honor any preferred treatment by prudent energy management and exert a relentless effort to improve energy efficiency in agricultural production. We may soon be talking about producing 50 percent more food with 30 percent less energy.

As a matter of putting agricultural energy demands in proper focus, let us examine the facts. In 1974, the total U.S. energy budget was 18.9×10^{15} or 18.9 quadrillion kilocalories. The U.S. food energy intake is approximately 3,300 kilocalories per person

per day, or 258 trillion per year for the entire population. Therefore, the total energy consumption for the U.S. is nearly 75 times the food energy consumed by its population.

Total energy requirements for direct agriculture, including the energy to manufacture fertilizers, farm equipment, etc., is approximately 500 trillion kilocalories or 2.7 percent of the U.S. total. As shown in Table 1, another 13 percent of the nation's total energy usage is required to process, distribute and prepare the food, so the all inclusive share of energy to put food on the table is approximately 16 percent or about 1/6 of the total U.S. energy budget.

Table 1

ENERGY REQUIRED FOR
FEEDING THE U.S. POPULATION

Source	Percent	
	of agriculture	of all U.S. usage
on the farm	17	2.7
processing	22	3.4
transportation	13	2.1
selling	17	2.6
preparation	31	4.9
TOTAL	100%	15.7

Oklahoma is an efficient producer of food energy. As shown in Table 2, our total food production is approximately 17 trillion calories per year or 6.4 percent of the nation's total food energy. Our State's agriculture directly consumes about 12.9 trillion kilocalories per year or 2.59 percent of the total U.S. energy used for direct agriculture (not including processing, distribution and

preparation). There are two reasons why Oklahoma produces a higher percent of the nation's food energy than it consumes. First of all, a high percent of our state's grain production is food grains such as wheat. Secondly, we market a lot of food energy in meat products, particularly beef that is produced on hay, pasture, silage and other forages grown on land that would otherwise be of little value to produce either feed or food grain. Illinois and other midwest states are heavily oriented to corn production which is a feed grain. Feed grains processed through livestock have a much lower conversion rate than food grains for human food.

Table 2

FOOD PRODUCTION
1974

U.S. Total	258×10^{12} kcal.
Oklahoma	
food grains	15.6×10^{12} kcal.
animals	1.0×10^{12} kcal.
TOTAL	16.6×10^{12} kcal.
Oklahoma produces 6.4 percent of the U.S. food energy requirements.	

Even though Oklahoma is in a favorable position from the standpoint of efficient use of energy in food production, we are still committed to manage our energy resources as efficiently as possible. With proper educational programs and economic incentives, Oklahoma agriculture could cut its energy consumption by 5 to 10 percent or save between 20 and 40 million gallons of diesel fuel equivalent per year. Such reductions could be made without cutting back on food production.

Along with many other efforts in Oklahoma, Agricultural Engineering Departments are now devoting major efforts through research programs to find new and practical uses of alternative energy sources to work towards an agriculture that could be energy independent. For example, they are researching on solar heat for drying, and livestock environments. Meanwhile, the extension programs are showing farmers how to conserve energy without restricting food production.

CHAPTER X

IMPORTANT ENERGY WORDS

Atom--The basic building block of all matter, an atom is the smallest particle of a chemical element (such as iron, hydrogen, gold, or uranium) that still has the properties of that element.

Barrel--Although seldom put in actual "barrels," crude oil is measured in a unit called the barrel, equal to 42 U.S. gallons.

Breeder Reactor--A Nuclear reactor that makes more nuclear fuel than it uses, by changing certain atoms that will not split into atoms that will split.

British Thermal Unit (BTU)--The amount of heat necessary to raise the temperature of one pound of water 1 degree Fahrenheit.

Calorie--The amount of heat needed to raise the temperature of 1 gram of water 1 degree Celsius; about as much heat as is given off by burning one wooden kitchen match.

Coal--A solid fuel, mostly carbon, formed from the fossils of plants living hundreds of millions of years ago.

Coal Gasification--A chemical process to change coal into a fuel similar to natural gas; the biggest advantage is that sulfur and other pollutants in coal can be removed before it is burned.

Coal Liquefaction (Coal Hydrogenation)--A chemical process to change coal into liquid fuels similar to gasoline and kerosene; compare with coal gasification.

Coolant--Anything pumped through a nuclear reactor to cool it or absorb the heat it produces. Common coolants are water, air, helium, and liquid sodium metal.

Critical Mass--The smallest amount of nuclear fuel, like uranium, that will sustain a nuclear chain reaction of splitting atoms.

Crude Oil--Liquid fuel formed from the fossils of animals and plants at the bottom of ancient seas; petroleum as it comes from the ground.

Deep Mining--Mining that must be performed by digging underground shafts and tunnels.

Depletion Allowance--A Federal tax exemption for a portion of the net income received from producing a natural resource. The amount

of the exemption is based on the perceived importance of the energy resource.

Direct Energy Conversion--The process of changing any other form of energy into electricity without machinery that has moving parts. For example, a battery changes chemical energy into electricity by direct energy conversion.

Efficiency, Thermal--A measurement of how efficiently any device changes heat into another energy form. For example, a modern coal-burning electric plant has about 38 percent thermal efficiency because just under 4/10 of the heat from burning the coal is actually changed into electricity.

Energy--The ability to do work or to make things move.

Fission--The splitting of the nucleus (or center) of one atom into two or more smaller atoms; fission often releases large quantities of energy.

Fission Products--The smaller atoms formed when atoms fission or split.

Fly Ash--Tiny particles of solid ash in the smoke when fuels such as coal are burned.

Fossil Fuels--Coal, petroleum, and natural gas; this term applies to any fuels formed from the fossils of plants and animals that lived eons ago.

Fuel--Anything that can be burned or fissioned to produce heat energy.

Fuel Cell--A device similar to a battery in which fuels such as hydrogen gas or methane can be directly combined with oxygen to produce electricity and very little heat; the principal by-products of the process are water or carbon dioxide.

Fusion--The process of combining the nuclei or centers of two light atoms to form a heavier atom; fusion can release great quantities of energy. The sun produces its energy by fusion.

Gas Cooled Reactor--A nuclear reactor that is cooled by a gas like air or helium, rather than by water or other liquid.

Gaseous Diffusion--A process by which natural uranium is enriched and becomes a better nuclear fuel.

Geothermal Energy--Heat energy produced deep within the earth largely by radioactive materials that occur there naturally.

Geothermal Steam--Steam formed by underground water seeping through hot rocks deep beneath the earth's surface.

Horsepower--A unit that measures the rate at which energy is produced or used. A man doing heavy manual labor produces energy at a rate of about .08 horsepower.

Kilowatt--A unit that measures the rate at which energy is produced or used. Ten 100-watt lightbulbs use energy at the rate of one kilowatt (equal to 1000 watts). A rate of one kilowatt maintained for one hour produces or uses one kilowatt-hour of energy (equal to 1000 watt-hours).

Magnetohydrodynamics (MHD)--Process that uses a magnetic field to produce electricity directly from the hot smoke and gases we get from burning fuels like coal and oil.

Megawatt--Unit to measure the rate at which energy is produced or used; it is equal to 1000 kilowatts (see kilowatt).

Moderator--Material, such as water and graphite, used in a nuclear reactor to slow the speed of neutrons produced when atoms split.

Natural Gas--Gaseous fuel formed from the fossils of ancient plants and animals; often found with crude oil.

Natural Uranium--Uranium as it is found in the ground; a mixture of two types of uranium atoms. Less than 1 percent of the atoms in natural uranium are the kind that will produce energy in a nuclear reactor.

Neutron--A tiny particle, extremely heavy for its size, often found in the nucleus of an atom. Neutrons have no electrical charge, and are released when atoms split (fission).

Nuclear Power--The energy produced by splitting atoms (such as uranium) in a nuclear reactor.

Oil Shale--Rock formed by silt and mud settling to the bottom of ancient seas that contains a substance similar to crude oil. So-called shale oil can be removed from the rock by heating and then used to make gasoline, kerosene, etc.

Petrochemicals--Chemicals removed from crude oil at the refinery and used to make a wide range of products such as plastics, synthetic fibers, detergents, and drugs.

Photosynthesis--The process by which green plants convert sunshine into chemicals.

Plutonium--A heavy, man-made radioactive metal that can be used for fuel in a nuclear reactor.

Power--The rate at which work is performed or energy is expended.

Radioactivity--A spontaneous change in the nucleus or center of an atom, accompanied by the release of energy called nuclear radiation.

Rem--(Acronym for Roentgen Equivalent Man) The unit of dose of any ionizing radiation which produces the same biological effect as a unit of absorbed dose of ordinary x-rays.

Solar Energy--The energy received from the sun. Nuclear and geothermal energy are the only presently available energy forms not derived from the sun.

Solar Power--Electricity, heat, or other useful energy produced from sunshine.

Steam Electric Plant--An electric power plant (either nuclear or one that burns coal or other fuel) in which heat boils water into steam, the steam is used to turn a turbine, and the turbine turns a generator to produce electricity.

Strip Mining--Mining for coal or useful ores by removing the soil and rock found above them, rather than by tunneling underground.

Surface Mining--A synonym for strip mining.

Therm--A unit of heat equal to 100,000 BTU's.

Thermal Pollution--Harmful effects to the environment that may be produced by the warm water released by electric power plants into nearby lakes, rivers, or oceans.

Wastes, Radioactive--A by-product of producing power by splitting atoms in a nuclear power plant; some of these materials are highly radioactive and stay radioactive for long periods of time.

Watt--The amount of power available from an electric current of 1 ampere at a potential of 1 volt.

Work--When the motion of matter is changed.

CONVERSION OF ENERGY UNITS

Energy Units Translated into BTU's	BTU's	Kilocalories
1 kilowatt-hour	3,412	860
1 ton of coal	25,000,000	6,300,000
1 bbl crude oil	5,800,000	1,461,600
1 gallon gasoline	125,000	31,500
1 gallon No. 2 fuel oil	140,000	35,280
1 cubic foot of natural gas	1,031	260
1 therm of gas (or other fuel)	100,000	25,200
1 cord of wood	20,000,000	5,040,000

One heating unit (therm) = 100,000 BTU's
1 therm = 15 lbs. coal = 1 gal. gasoline = 120 cubic feet natural gas = 30 kilowatt hours of electricity
1 bbl crude oil = 350 lbs. of coal = 500 kilowatt hours
1 kilowatt = 1 1/3 horsepower

Metric Conversion

1 kilowatt-hour = 3.6×10^{6} Joules
4.2 Joules = 1 calorie
1 calorie = 1.17×10^{-6} kilowatt-hour
1 calorie = 4×10^{-3} BTU's
1 Calorie (kilocalorie) = 3.968 BTU's

CHAPTER XI

SOME SELECTED SOURCES OF ENERGY INFORMATION
State of Oklahoma

Industry

Energy Information
Cities Service Company
Box 300
Tulsa, Oklahoma 74102

Oklahoma Gas & Electric Co.
P.O. Box 321
Oklahoma City, Oklahoma 73101

Gulf Oil Corporation
P.O. Box 661
Tulsa, Oklahoma 74102

Phillips Petroleum Company
Bartlesville, Oklahoma 74004

Public Service Company
Tulsa, Oklahoma

Continental Oil Company
P.O. Box 1267
Ponca City, Oklahoma 74601

Oklahoma Petroleum Council
1615 Fourth National Bank Bldg.
Tulsa, Oklahoma 74119

Government

State Department of Education
2500 N. Lincoln Blvd.
Oklahoma City, Oklahoma 74105

Department of Energy
4400 N. Lincoln Blvd., Suite 251
Oklahoma City, Oklahoma 73105

Oklahoma Geological Survey
The University of Oklahoma
Norman, Oklahoma 73069

U.S. Department of Commerce
4400 N. Lincoln Blvd.
Oklahoma City, Oklahoma 73105

Organizations Outside Oklahoma

Federal Energy Administration
Office of Public Affairs
2000 M Street, N.W.
Washington, D.C. 20036

National Center for Community Action
Network Services: Energy
1711 Connecticut Ave., N.W.
Washington, D.C. 20009

Department of Housing and Urban Development
Washington, D.C. 20410

ERDA-Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

U.S. Department of the Interior
18th and C Street, N.W.
Washington, D.C. 20240

National Audubon Society
1130 Fifth Avenue
New York, New York 10028

Organizations Outside Oklahoma (Continued)

Shell Oil Company
One Shell Plaza
Houston, Texas 77002

Sierra Club
1051 Mills Tower
San Francisco, California 94104

National Science Teachers Assoc.
1742 Connecticut Ave., N.W.
Washington, D.C. 20009

American Petroleum Institute
1801 K Street, N.W.
Washington, D.C. 20006

American Public Power
Association
2600 Virginia Avenue, N.W.
Washington, D.C. 20031

PUBLICATIONS AVAILABLE FROM:

Energy Research and Development
Administration
P.O. Box 62
Oak Ridge, Tennessee 37830

Energy

IB-021 Creating Energy Choices for the Future: A Summary of the National Plan for Energy Research Development and Demonstration

IB-020 The Economics of America's Energy Future

IB-1002 Energy Technology

Environment and Safety

IB-105 The Genetic Effects of Radiation

IB-204 Nuclear Power and the Environment

IB-109 Your Body and Radiation

IB-414 Nature's Invisible Rays

IB-412 Space Radiation

Solar, Geothermal, and Advanced Energy Systems

IB-403 Controlled Nuclear Fusion

IB-701 Geothermal Energy

IB-801 Solar Energy

IB-405 The Elusive Neutrino

IB-416 Inner Space: The Structure of the Atom

MOVIE FEATURETTES

The following film featurettes were produced by the American Petroleum Institute. They are available on a limited basis from the Oklahoma Petroleum Council, with only a few prints of each in the Council's Film Library. Be sure to specify several alternate preferred showing dates for these:

ALASKA: ENERGY FOR TOMORROW--A colorful, scenic movie that examines the construction taking place on the $6.8 billion Trans-Alaska pipeline from the frozen North Slope to the ice-free port of Valdez. It tells the part this petroleum supply eventually will play in America's energy future (10 minutes, color--1975).

GATEWAY TO ENERGY--Provides a brief, informative look at a petroleum refinery. Two spokeswomen conduct an informal discussion with a technical expert to point out why these facilities are so essential to the nation's energy needs (6 minutes, color--1974).

UNDERSEA SEARCH FOR OIL--This brief film gives a close-up look at an off-shore petroleum platform in a different and entertaining way (5 minutes, color--1973).

CONSERVATION CONVERSATION--A quick look at timely energy conservation tips for home and driving (3½ minutes, color--1974).

Free on Loan:

Modern Talking Picture Service, Inc.
1411 Slocum Street
Dallas, Texas 75207

1. Energy: Critical Choices Ahead--approximately 30 minutes.

2. World of Energy--approximately 30 minutes.

3. When the Circuit Breaks--FEA--approximately 30 minutes.

4. Clean Energy--approximately 30 minutes.

Shell Film Library
1433 Sadlier Circle, W. Drive
Indianapolis, Indiana 46239

1. Fossil Story--20 minutes.

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1. A Teacher's Guide for Energy Conservation, Environmental Center, University of Tennessee, Knoxville, Tennessee.

2. A Teacher's Handbook on Energy, Colorado Department of Education, Denver, Colorado, 80203; 1974.

3. Beyond the Rhetoric; An Assessment of America's Energy Options, Energy Information, Cities Service Company, Box 300, Tulsa, Oklahoma, 74102.

4. create tomorrow...today; energy awareness program - secondary, State of Washington, Superintendent of Public Instruction, Old Capitol Building, Olympia, Washington, 98504; 1974.

5. Educators Progress Guide to Free or Inexpensive Science Materials, Educators Progress Service. Inc., Randolph, Wisconsin.

6. Energy Activities for the Classroom, ERIC Center for Science, Mathematics, and Environmental Education, Ohio State University, 1200 Chambers Road, Columbus, Ohio, 43212; 1976.

7. Energy Activities for the Classroom, West Virginia Department of Education, 1975.

8. Energy Activities With Energy Ant, Federal Energy Administration, Office of Communications and Public Affairs, Washington, D.C., 20461.

9. Energy and Man's Environment; Elementary Through Secondary Inter-Disciplinary Activity Guide (Second Revised Discussion Draft), Superintendent of Public Instruction, Washington State, Office of Environmental Programs in cooperation with The Oregon State Department of Education and The Idaho Department of Education, 1973.

10. Energy: A Teacher's Introduction to Energy and Energy Conservation, Ohio Department of Education, Columbus, Ohio, 43215; 1975.

11. the energy book, South Carolina Department of Education, Columbia, South Carolina, 29201.

12. The Energy Challenge; An Activity Master Program About Our Energy Past, Present, and Future for Grades 5 through 8, Federal Energy Administration, Washington, D.C.; 1976. (To obtain at no charge, write to: The Energy Challenge, Box 14303, Dayton, Ohio, 45414)

13. Energy Conservation; Understanding and Activities for Young People, Office of Energy Conservation, Federal Energy Administration, Washington, D.C., 20461; 1975.

14. Energy-Environment Materials Guide, National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C., 20009; 1975.

15. Energy-Environment Mini-Unit Guide, National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C., 20009; 1975.

16. Energy-Environment Source Book, National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C., 20009; 1975.

17. Energy in Oklahoma, Final Report of Oklahoma Energy Advisory Council, Oklahoma Department of Energy, 4400 North Lincoln, Oklahoma City, Oklahoma, 73105; 1974.

18. Energy Materials, State of Iowa, Department of Public Instruction, Grimes State Office Building, Des Moines, Iowa, 50319.

19. Energy Reporter, periodical published monthly by FEA's Office of Communications and Public Affairs, Energy Reporter, FEA, Washington, D.C., 20461. (To obtain free subscription, mail request to: Energy Reporter, FEA, Suite 412, 6611 Kenilworth Avenue, Riverdale, Maryland, 20840)

20. Environmental Education Instructional Activities Booklet, Oklahoma State Department of Education, Oklahoma City, Oklahoma, 73105; 1975.

21. The Farkleberry Cookbook in Environmental Education: An Activity Guide for Creative Teachers, Arkansas Department of Education, Little Rock, Arkansas, 72201; 1975.

22. Geology and Earth Resources of Oklahoma; An Atlas of Maps and Cross Sections, Oklahoma Geological Survey, The University of Oklahoma; and Oklahoma State Department of Education, 1972.

23. Living Within Our Means: energy and scarcity; Environmental Education Instructional Activities, (K-6 and 7-12), The University of the State of New York, The State Education Department, Albany, New York, 12234.

24. Teaching Activities in Environmental Education, ERIC Center for Science, Mathematics, and Environmental Education, Ohio State University, 1200 Chambers Road, Columbus, Ohio, 43212; Vols. I and II, 1974; Vol. III, 1975.